General Application Name: Public Works/Service Authority

Product / Service / Function Name: Water Meter Location Inventory

P/S/F Description:

A water meter is a device that is used to measure water consumption at a residence or business location. A water meter location inventory refers to the cataloging of water meters and their locations within a municipal water system. The inventory process includes physically locating all water meters in the water system and noting their locations as well as gathering the descriptive information about each meter (such as size). Inventories are used to maintain and upgrade the system of meters by keeping track of the age, condition, and other information. Water usage data, collected by the meters, is used to calculate water bills. Therefore, keeping an up-to-date inventory of water meters allows utility officials to correctly calculate bills, replace meters when needed, and plan for the future based on current water usage. A GIS is ideal for maintaining this type of inventory because of its ability to map and query the data.

Product / Service / Function

1. Spatial Data

Minimum Data Requirements

General Description	GIS Data Layer
Utilities Data	Meters
	Water lines
Planimetrics/Base Mapping	Buildings
	Parcels
Transportation	Right-of-way and/or edge of pavement
	Parking lots
Socio-Political Data	Municipal boundaries

Optional Data Requirements

General Description	GIS Data Layer
Utilities Data	Sewer lines
	Water valves
	Manhole locations
	Stormwater drainage
	Treatment plants/pump stations
	Tanks/wells
	Fire Hydrants
Planimetrics/Base Mapping	Orthophotography
	Zoning
Natural Features	Vegetation
	Flood zones
	Streams/rivers
	Ponds/lakes

Transportation	Centerlines
	Railroads
Socio-Political Data	Neighborhoods & Subdivisions
Other	Billing database (customers/usage history)

2. Attribute Data

Minimum Attribute Requirements

GIS Data Layer	Attributes
Meters	Install Date
	Meter Type
	Location Description
	Flow Range
	Meter Size/Diameter
	Meter ID
	Condition of meter
Water lines	Diameter
Buildings	Address
Right-of-ways	Street names

Optional Attribute Requirements

GIS Data Layer	Attributes
Meters	Work Order ID
	Set Date
	Last Inspection Date
	Last Meter Reading & Date
	Account/Customer Number (for link to billing data)
Water lines	Material
	Install Date
Water Valves	Valve Type
	Diameter
Buildings	Owner name
Parcels	Dimensions
Street centerlines	Address ranges
	Street names

3. Data Acquisition Options (integrated with VBMP digital orthos)

The most critical data layer is the meter locations. The most efficient way to acquire the location of meters is by collecting Global Positioning Systems (GPS) data. In some municipalities, the meter readers are trained to use GPS equipment so that they can acquire positions on their regular meter-reading routes. Another option is to hire a GPS consulting firm to collect the meter

locations. Typically, GPS data is not downloaded and attributed until the operator is back in the office. However, technology now allows GPS receivers to link directly to GIS software in laptop computers or handheld devices in the field. This allows the data collector to interactively attribute each meter with the correct information as the GPS is calculating the position. Most GIS software programs and GPS units provide a utility that converts the GPS locations into a GIS-friendly format.

Base mapping and planimetric data are typically generated at the county or city level. This data may be produced in-house or the project may be contracted out to a consulting firm. This data often includes tax parcels, zoning districts, land use, parks, open water, right-of-ways, railroads, and building footprints. Street centerline data layers of varying qualities can be obtained from a number of vendors. The market is relatively competitive, and prices will vary with quality of the data. Relevant vendors that provide this kind of spatial data on a regional and national scale include: NAVTECH <www.navtech.com>, GDT <www.geographic.com>, and TeleAtlas <www.teleatlas.com>.

Other spatial data layers can be obtained through the Internet from various government sources. Municipal boundaries and similar layers can be obtained in digital format through the U.S. Census Bureau <www.census.gov>. Floodplains can be obtained through the FEMA Web site <www.fema.com>.

Regardless of the source of the data, each data layer used to build the water meter location inventory should be consistent with, or be modified to match, the Virginia Base Mapping Project orthophotography. This is vital for data consistency across the state and facilitates data sharing across jurisdictional boundaries. The digital orthophotography provides an excellent base data layer on which to display the meter data and create map books for field use.

4. Data Conflation Options (integrated with VBMP digital orthos)

Data conflation is a process by which two digital data layers, usually of the same area at different points in time, or two different data layers of the same area, are geographically "corrected" through geometrical and rotational transformations so that the different layers can be overlaid on one another. Also called "rubber-sheeting," this process allows a technician to adjust the coordinates of all features on a data layer to provide a more accurate match between known locations and a few data points within the base data set. A good base layer to use for data conflation is the VBMP orthophotos since many features can be seen or interpreted. The need and processes for conflation varies between sets of data, users, and feature types. Any dataset that is updated independently by different departments can be consolidated through conflation. Within most local governments, individual departments are responsible for maintaining specific datasets within their expertise; therefore, conflation is not often necessary. Often, reprojecting the data into a different coordinate system will take care of the misalignment of different data sets. Most industry-standard GIS software has the ability to perform data conflation.

In the case of a water meter location inventory, is important to either capture the GPS meter locations in the same projection as the VBMP orthophotography or reproject it later to match the orthophotos. This ensures that when the GPS meter locations are converted into a GIS data layer, the meters will appear in the correct location on top of the orthophotos.

5. GUI / programming option

There are many options for developers of a GIS-based water meter location inventory system. The following are three approaches:

- Standard GIS desktop application that can be customized to the user's needs
- Existing commercial water meter inventory and mapping system
- Hiring a consultant to develop a custom system from scratch.

Using a standard GIS application often requires a significant amount of training and customization. Whereas the initial cost may be lower, the time invested in learning these solutions may generally increase the overall expense of implementation. However, standard GIS packages deliver more robust data integration, analysis, and cartographic capabilities than do other specialized commercial applications. They have a greater user support infrastructure that allows users to overcome problems quickly.

Standard GIS Software Vendors:

Vendor	Software	Web Address
ESRI	ArcView 3.x	http://www.esri.com
ESRI	ArcGIS 8.x	http://www.esri.com
MapInfo	Professional 7.0	http://www.mapinfo.com
Intergraph	GeoMedia 5.0	http://www.intergraph.com/gis
Autodesk	Map 5.0	http://www.autodesk.com

There are an increasing number of vendors developing and implementing utilities management software, including components for meter inventory. These products may cost more than standard GIS software packages because of the customization that is required to fit the application into the agency's business practices and/or connect to its data source (i.e. the server). The advantage is that a tailored application provides just the functionality that is needed, decreasing the overall application overhead common to industry-standard GIS software. Options for using an existing, commercial water meter inventory and mapping system include those listed in the following table:

Commercial Software:

Vendor	Product	Web Address
Azteca	CityWorks	www.azteca.com
CarteGraph	WATERview	www.cartegraph.com
Hansen	Hansen 7.5	www.hansen.com

The final option for developing and implementing a water meter location inventory system is to contract a consultant. This option makes certain that a product will fulfill an agency's requirements. Unlike the first option, which requires the user to modify its own process/technology to fit the GIS system, with customized solution, the system fits existing business practices. A consultant will be able to develop an application that works with the wide range of hardware and software that are currently in use within local governments within Virginia. Also, training and follow-up user support is often provided at a much more substantial level than with other options.

As an example, many local governments still house their water billing data in an AS/400 database. A consultant would be able to build an application that directly links the GIS data and

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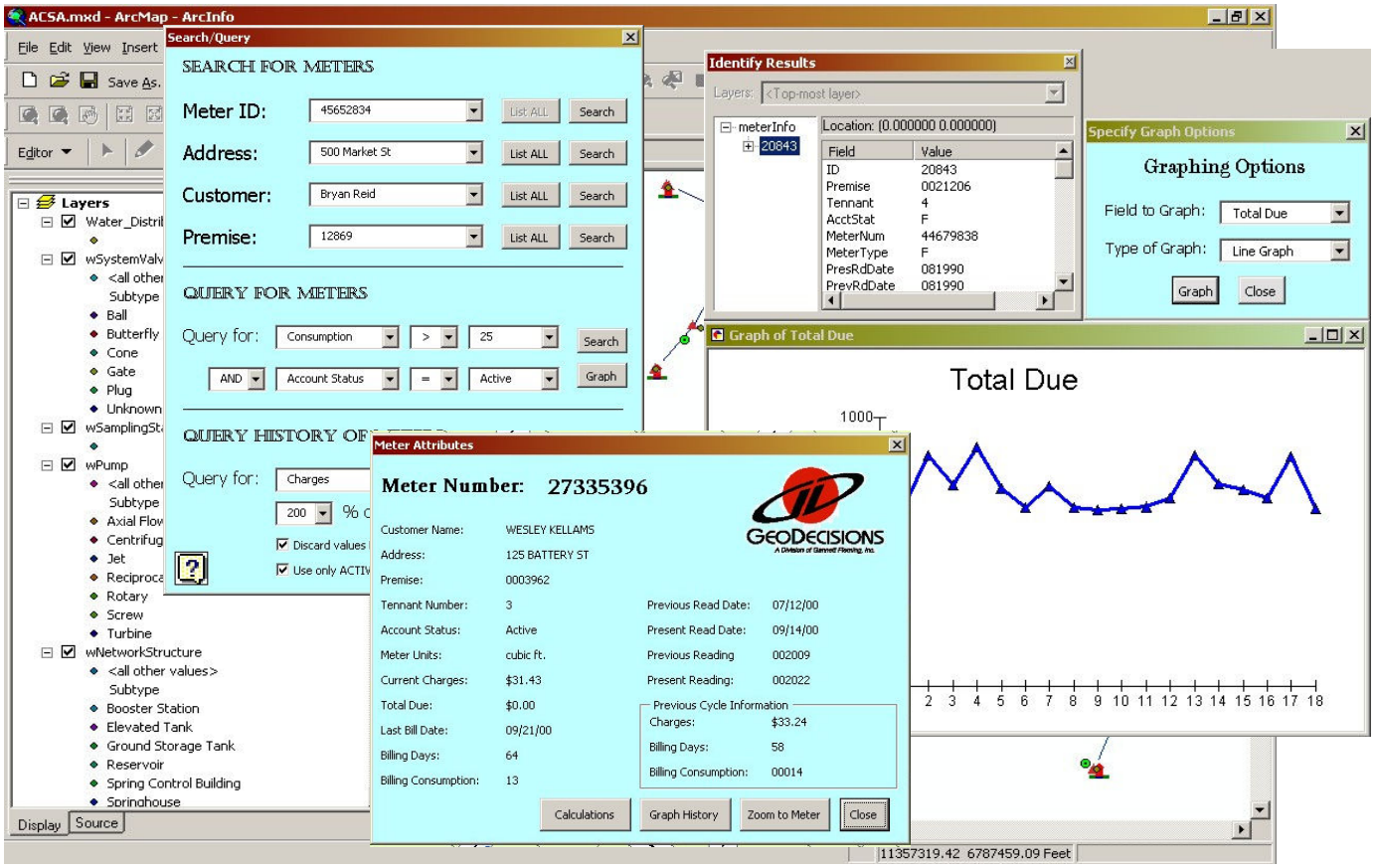
the AS/400 data with a custom interface. The user would be able to click on a meter in the GIS and see the entire history of that water meter. It is also possible to customize queries to find all inactive accounts or which meters have increased their consumption by a certain percentage. A pubic kiosk could be set up to reduce the amount of work for the customer service representatives.



Custom interface that links the water meters in GIS to the billing data from an independent database.

6. Internet Functionality and options

The Internet has proven itself as a viable solution for local governments to centralize the maintenance and management of services and data. As more local governments are implementing Web-based solutions, they are finding that the Internet requires them to change the nature of an application or its usefulness. Through the flexibility of an Internet solution, software can be easily updated, and users gain greater accessibility to the applications and information they need for their specific tasks through simple, user-friendly interfaces.

If a local government so chooses, they can deploy a Web GIS application to allow citizens of their community to view maps of the meter and water systems and the associated billing data. Customers could find out their water consumption history or even pay their water bills online. GIS software vendors have products that can be customized in-house or by a consultant to provide Web GIS applications on the Internet, over an intranet or via wireless network.

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GIS Internet Solutions

Vendor	Internet Software	Web Address
ESRI	ArcIMS	http://www.esri.com/software/arcims
MapInfo	MapXtreme, MapX	http://www.mapinfo.com
Intergraph	GeoMedia WebMap	http://www.intergraph.com/gis/gmwm
Autodesk	MapGuide	http://www.autodesk.com

7. Technical Requirements

Minimum Technical Requirements
At its most basic level, a water meter inventory location system can be used on a single, stand-alone workstation. This workstation would have a hard drive that stores all of the spatial data layers, as well as the GIS software package or application itself. A typical workstation running off-the-shelf software should have the following minimum specifications:

Processor: Pentium 3; 450 MHz
RAM: 128MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1: 19"
Floppy Drive: 3.5”
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
OS: Windows 2000/NT/XP
Office: Windows 2000 Professional
Printer: 8x11 office-grade color printer

Optimum Technical Requirements:
A more complex water meter inventory location system may require multiple components, including servers, desktop workstations, or ruggedized laptops, or handheld devices. The scale at which the system is implemented, thus the technical needs, is dependent on the number of daily GIS users as well as the number of data collectors. For either a client-server or a Web-based application, the system should rely on a fairly robust server computer and high-end workstations. Some examples specifications of the necessary equipment are listed below:

Server
Processor: Min. 2x Processors, 1.7 GHz, 512K cache
RAM: Min. 2x 512MB RIMMS
Hard Disk: Min. 2x 80GB +RAID
Monitor 1: 19"
Floppy Drive: 3.5”
CD-ROM: 12x/8x/32x CD drive
Modem: 56K
Network Card: 10/100 mbps

Workstation
Processor: Pentium 4, 1.5 GHz
RAM: 512MB SDRAM at 133MHz
Hard Disk: 20GB (min.)
Monitor 1: 19”

Monitor 2:	17”
Floppy Drive:	3.5”
CD-ROM:	12x/8x/32x CD-RW drive
Modem:	56K
Network Card:	10/100 mbps
OS:	Windows 2000/NT/XP
Office:	Windows 2000 Professional

Other Components

Printer:	8x11 office-grade color printer and 8x11 production b/w printer
Plotter:	HP DesignJet 1055CM
Tape Backup:	Tape Library Server
UPS:	APC 1400 (or other similar)
Scanner:	11x17
Handheld:	Compaq IPAQ
Network:	T1

8. Administrative/Management Requirements

At the beginning of the project, the assigned project manager from the particular municipality should consider completing some, if not all of the following tasks that relate to the administrative requirements of a water meter location inventory system:

- Determine, with or without the assistance of a consultant hired to develop the system, the preliminary vision and goals of the project.
- Coordinate an initial meeting with the decision-makers (i.e. the Board of Supervisors, City Council, public works department, engineering department, etc.) where the vision and goals of the project are expressed and the background of GIS technology is described, if needed.
- Coordinate with other municipal agencies for data sharing provisions.
- Determine a mechanism of communication to keep the decision-makers aware of the progress of the project.
- Develop a basic understanding of the available precedents in the region/state and research the available technologies that can be applied to the project.

Upon project completion, a simple desktop water meter location inventory system will require very little administrative support. Administrative tasks may include loading or upgrading new versions of the software or patches, providing for constant data flow from the source database, and maintaining yearly support contracts on the hardware and software. However, once the system becomes distributed as an enterprise solution to many users throughout a department or deployed on the Internet, there are various other management requirements that need to be fulfilled on a weekly or monthly basis.

At the point where the system grows beyond single desktop users, a devoted administrator or system manager needs to be established. This is essential for the following reasons:

- The system will now be interfacing with other technology systems already in place. Therefore, someone needs to maintain contact with the technology personnel that maintain these systems.
- The manager needs to put into place training schedules to maintain user knowledge of the system.

- Funding will undoubtedly be required to either maintain the system long-term, or continue to expand the system, which requires funding research and applications for grants.

9. Cost – Cost/Benefit

Hardware	**Typical Unit Cost**
Minimum Workstation	$2,000
Optimum Workstation	$3,200
Laptop	$2,400
Web/FTP Server	$8,500
Database Server	$12,000
Data Warehouse Server	$18,000
Backup Server	$5,800
Printer (8x11 color)	$700
Printer (8x11 b/w production)	$2,000
Plotter	$12,000
Tape Library	$5,000
UPS (Universal Power Supply)	$700
Scanner	$1,500
Handheld	$300-$700
GPS equipment (for in-house work)	$5000-$15,000

Software (all prices included license)	**Typical Unit Cost**
Off-the-shelf GIS desktop software	$700-$10,000
Commercial meter inventory software	$2,000-$6,000
Customized desktop vendor solution	$5,000-$15,000
Web-based vendor application	$15,000-$25,000
Customized web-based vendor solution	$20,000-$60,000

Miscellaneous	**Typical Unit Cost**
GPS survey by a consultant	$15,000-$90,000 (depends on # features)
Training – focused meter inventory system training (per person)	$700-$1,000
Training – general GIS	$700-$1,200
Licensing – desktop	$100-$500
Licensing – webapp (1st CPU)	$7,500-$12,000
Maintenance (per year)	$8,000-$15,000

10. Standards / Guidelines Summary

- Research the historical documentation for the location of the meters before establishing a budget. Budgeting on a per meter basis could cause the project to run over if there are more meters in the field than anticipated.
- Consider collecting too many attributes rather than not enough. It may be too expensive to go back later and re-survey to obtain attributes that were left out in the first pass.

- Create a "data dictionary" before the survey to ensure all data collectors are collecting the same information about the meters in the same format.
- Create a realistic schedule for the GPS meter survey. Consider the amount of effort as well as data accuracy requirements and number of features.
- Do a "pilot area" first to review initial data collected to see if a revised plan is needed before moving on to the rest of the inventory.
- Develop a detailed Quality Assurance/Quality Control (QA/QC) procedure for reviewing the accuracy of the meter locations and their attributes.
- Consider inventorying other utilities at the same time the meters are located with GPS. This is a potential cost savings.
- Maintain data in the VBMP standard coordinate system (Virginia State Plane, NAD 83, Survey Feet).
- Create metadata (standard information about GIS data) for each data layer. Metadata tracks the date, origin, coordinate system, and other such information for data layers.

11. Startup Procedures/Steps

A water meter inventory is a large project. Therefore careful planning will make the process go much more smoothly. There are at least eight steps involved with doing the water meter inventory and developing a GIS-based water meter location inventory system. The steps can be performed in-house or by a consulting team.

The first task is to complete a detailed Needs Assessment. This process gathers information regarding existing operational procedures, hardware and software, GIS data, and personnel needs. It should include interviews of key individuals throughout the local government agency and other related government departments to obtain a comprehensive view of the agency's operations, and where GIS might improve them. Basic GIS concepts should be discussed and illustrated to those interviewees that have little prior understanding of GIS. A comprehensive Needs Assessment should then be compiled from the results of the interviews. This document explains the various requirements for a water meter location inventory system in the following areas: personnel needs, spatial data development needs, applicable spatial analysis techniques, basic system requirements, including preliminary, general hardware and software recommendations, and training needs.

The second task is to develop a functional requirements document for the proposed system. This document should describe, as completely as possible, all of the technology and functionality that is to be included in the water meter location inventory system. This document is used by the local government agency, or its consultant, as the blueprint for the GIS application or system. It should include:

- Hardware specifications
- Software purchases
- Detailed descriptions of work-flow, and examples of the graphic user interfaces
- Describe each tool that is part of that graphic user interface, and its functionality
- Describe how data would flow between the different databases and data warehouses, if applicable
- Describe the redundant security measures that will be put in place to make certain of data integrity and confidentiality, when applicable
- Analytical techniques that the application/system provides the user for meter queries and usage analysis

- Describe each of the potential products (reports, maps, charts, summary tables) that the user will be able to generate within the system

The third task should be to compile or develop a water utilities spatial data set that can be used by the evolving water meter location inventory system. Data can be gathered from a number of online sources, as well as county/city departments. The data layers gathered and maintained should match at least the minimum list provided in Section 1 of this document. At this point, the GPS survey of water meters should begin.

On completion and acceptance of the functional requirements document and the development of the spatial and attribute data, the system development and test phase can begin. During this time, the application will be customized as it was outlined in the functional requirements phase. The local government agency should require periodic reviews of the application at particular milestones, such as 50% and 75% completion. This will make certain that problems with the application will be recognized early in the development process, and that the local government agency remains a part of the development process throughout the project timeline.

When the system is nearing 100% completion, it should be installed and tested in the environment in which it will ultimately be used. This allows the users to test the system alongside the application developers, and determine any system integration problems that might arise. It also gives the developers the opportunity to test the application's functionality in a real-world situation. This testing process should be as comprehensive as possible. Each process detailed within the functional requirements should be tested and evaluated at this point.

User training commences once the application reaches 100% completion and is fully documented. Different levels of tutorials and system documentation should be developed depending on the hierarchy of users. Time should be spent at this stage of the project with each potential user of the system to make certain that the proper education occurs. Training should be done through lessons that use real-life examples of the system application. This strategy greatly enhances users' ability to apply the functionality to their jobs.

The next phase of the project should include a document that describes a future plan for wider system development. This document accomplishes two goals. The future plan gives the local government agency ideas on how the system might grow to assist other facets of its business practices. Secondly, it provides the agency with a ready-made grant proposal for applying for potential funding sources.

The final phase of a successful water meter location inventory system is ongoing technical support. The local government agency should always include this contingency within its cost estimates of a project for a minimum of three months after a system has been put into place. No matter how effective an application appears, problems and system changes inevitably impact the functionality of an application.

12. Estimated time line and/or implementation (stand alone) schedule

Phase	Approximate Duration
RFP/Contract process (construction, posting, proposal acceptance, review, award of contract)	4 months - 1 year
Needs Assessment	2 months

Functional Requirements	1-2 months
Data Development	6-12 months
System Development and Testing	2-4 months
Installation and Testing	1 month
User Training	½ month
Plan for Future Development	½ month
Ongoing Support	3 months

13. Best Practice Examples in Virginia

Augusta County Service Authority
18 Government Center Lane
Verona, VA 24482
(540) 245-5670
http://www.acsawater.com/

City of Newport News
GIS - Waterworks
700 Town Center Drive
Newport News, VA 23607
(757) 247-2640
http://www.nngov.com

Henrico County
4301 E. Parham Rd
Richmond, VA 23228
(804) 501-5769
http://www.co.henrico.va.us